

## CLAIMS:

1. An optical scanning device for scanning a multi-layer optical record carrier when positioned in a scanning location in the device, the device being adapted for scanning a first information layer at a first information layer depth within the record carrier and a second information layer at a second information layer depth within the record carrier, the device comprising:
  - a radiation source for generating a radiation beam;
  - an objective lens, located in an optical path between the radiation source and the scanning location, for converging a radiation beam to a spot on an information layer; and
  - 10 - an optical switching arrangement switchable between a first state, in which the device is arranged to scan a said first information layer, and a second state, in which the device is arranged to scan a said second information layer,

wherein the optical switching arrangement comprises a compensator arranged to generate a different amount of spherical aberration in a radiation beam when in said first state and when in said second state,

characterised in that the compensator is further arranged to generate a different amount of vergence in a radiation beam when in said first state and when in said second state,

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the different amounts of spherical aberration and vergence being selected such that a free working distance between said objective lens and said optical record carrier
  - 15 20 remains substantially constant when switching between said first and second states.
2. An optical scanning device according to claim 1, wherein a change in free working distance ( $\Delta f_{wd}$ ) when switching between said first and second states is less than 5% of a difference ( $\Delta d$ ) in the first and second information layer depths.
- 25 3. An optical scanning device according to claim 2, wherein the change in free working distance ( $\Delta f_{wd}$ ) is less than 1% of the difference ( $\Delta d$ ) in the first and second information layer depths.
- 30 4. An optical scanning device according to any preceding claim, wherein a change in free working distance ( $\Delta f_{wd}$ ) when switching between said first and second states is less than a focal tolerance  $\Delta z$ :

$$\Delta z = 0.5 \frac{\lambda}{NA^2}$$

where  $\lambda$  is the wavelength of the said radiation beam and NA the numerical aperture of the objective lens.

5. An optical scanning device according to any preceding claim, wherein said compensator comprises a set of fluids having a switchable configuration.
6. An optical scanning device according to claim 5, wherein said set of fluids provides a fluid meniscus of which the shape is varied when switching between said first and second states to provide the different amounts of spherical aberration and vergence.
- 10 7. An optical scanning device according to any of claims 1 to 4, wherein said compensator comprises a grating element arranged to provide the different amounts of spherical aberration and vergence.
- 15 8. An optical scanning device according to any of claims 1 to 4, wherein said compensator comprises a phase structure having a non-periodic pattern which does not regularly repeat in a radial direction on the compensator, the phase structure being arranged to provide the different amounts of spherical aberration and vergence.
- 20 9. A method of operating the optical scanning device of any preceding claim, comprising reading data from the record carrier during a scanning operation conducted on one information layer, and altering the optical characteristics of the optical switching arrangement in order to compensate for a wavefront aberration generated in the record carrier when conducting a subsequent scanning operation on the other layer.
- 25 10. A method of operating the optical scanning device of any of claims 1 to 8, comprising writing data to the record carrier during a scanning operation conducted on one information layer, and altering the optical characteristics of the optical switching arrangement in order to compensate for a wavefront aberration generated in the record carrier when 30 conducting a subsequent scanning operation on the other information layer.
11. An optical element adapted for use in an optical scanning device for scanning a multi-layer optical record carrier when positioned in a scanning location in the device, the device being adapted for scanning a first information layer at a first information layer depth

within the record carrier and a second information layer at a second information layer depth within the record carrier, the device comprising:

- a radiation source for generating a radiation beam;
- an objective lens, located in an optical path between the radiation source and
- 5 the scanning location, for converging a radiation beam to a spot on an information layer; and
- an optical switching arrangement switchable between a first state, in which the device is arranged to scan a said first information layer, and a second state, in which the device is arranged to scan a said second information layer,
- wherein the optical element is arranged to be included in said switching
- 10 arrangement and to generate a different amount of spherical aberration in a radiation beam when the optical switching arrangement is in said first state and when in said second state,
- characterised in that the optical element is further arranged to generate a different amount of vergence in a radiation beam when in said first state and when in said second state,
- 15 - the different amounts of spherical aberration and vergence being selected such that a free working distance between said objective lens and said optical record carrier remains substantially constant when switching between said first and second states.